" SYNTHESIS AND CHARACTERIZATION OF GADOLINIUM (Gd^{3+}) DOPED Ni, Cu, Zn NANOFERRITES "

A

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INDEX OF THE RESEARCH PROPOSAL

Sr. No.	Contents	Page No.
	Abstract of proposed work plan/ problem	4
1	Introduction	5 -7
2	Review of Literature and Development in the subject (Previous work done in the relevant area)	7-13
3	a) Objectives of the Research b) Proposed Hypothesis	14 15
4	Methodology to be adopted	15-17
5	Importance of study/Society application	17-19
6	Proposed Work plan/Formulation and Structure of study	19-20
7	References	20-23

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PROPOSED WORK/PROBLEM:

"SYNTHESIS AND CHARACTRIZATION OF Ni, Cu, Zn NANOFERRITES DOPING GADOLINIUM (Gd^{3+}) BY SOL-GEL TECHNIQUE"

Abstract:-

In the present work, Nickel, Copper, Zinc substituted rare earth element Gadolinium (Gd^{3+}) Nano ferrite as (A)x (B) y Fe2 - yO4 where "A" is the combination of Ni, Cu, Zn metal oxide and "B" is rare earth metal oxide (Gd^{3+}) (Where as x = 1 and y = 0.025, 0.05, 0.075, 0.1, 0.125) Prepare by sol-gel auto combustion method. All materials are in nitrate forms. The prepared sample characterized by TGDT (Thermo Gravimetric and Differential Thermal) and will be analyze for the phase formation. FT-IR (Fourier transform infrared) for confirmation of ferrites, UV-Visible for absorption spectra, SEM (Scanning Electron Microscopic) for surface morphology and XRD (X-ray diffraction) for determination of particle grain size and structural properties of the prepared samples. The dielectric permeability, AC resistivity and DC resistivity will be measure. VSM (Vibrating Sample Magnetometers) is used to study the magnetic properties of prepared nanoferrites. TEM (Transmission Electron Microscope) will be used to find plane, particle size and radii. This research work is expected to enhance the electrical and magnetic properties of the materials. The prepared samples have various applications in core material and electronic devices technology.

1. INTRODUCTION:

In the recent years, very much attention has been paid to the Nano-magnetic materials those show very interesting magnetic properties. In such material, different properties and various applications are appeared as compared to their bulk counterparts. The magnetic properties of Nano materials are used in Electronic, Medical, and Recording industries that depend on the shape, purity and magnetic stability, size of these materials. In biomedical application, one can use nano magnetic materials as drug carriers inside body, where the conventional drug may not work. For this purpose, the nano size particles should be in the super paramagnetic form with a low blocking temperature. Ferrite nano materials are object of intense research because of their proper magnetic properties.

Nano ferrites are simultaneously good magnetic and dielectric materials. These properties of the Nano ferrites are affected by the preparation conditions, chemical composition, sintering temperature and the method of preparation. Several physical and chemical methods, such as co-precipitation, combustion technique, sol-gel, high energy milling, spray pyrolysis etc. have been used for the fabrication of stoichiometric and chemically pure Nano ferrite materials.

Among the available chemical methods, the sol-gel technique is an excellent method to synthesize the rare earth substituted nanoparticles with maximum purity. In this, the structural and magnetic properties of gadolinium substituted Ni, Cu, Zn ferrite and XRD, SEM and DIelectrical properties will investigate.

Ferrites are a wide range of minerals and synthetic materials, Ferrites are chemical compounds obtained as powder or ceramic bodies with ferromagnetic properties formed by iron oxides as their main component, Fe2O3 and FeO, which can be partly changed by other transition metal oxides (Santina Mohallem,2012) which have attracted a wide range of scientists' interest due to their various applications. Ferrites in a nano crystalline state (i.e., below single domain sizes) are often found to have unique physical and mechanical properties compared to coarse-grained polycrystalline materials

Ferrites are technologically significant materials due to their unique electrical, dielectric, electronic, mechanical, magnetic, optical and catalytic properties. These ferrites are characterized by good magnetic properties, low ($NiFe_2O_4$) or high ($CoFe_2O_4$) magnetic coercivity, high electrical resistivity and negligible eddy current loss for high-frequency electromagnetic wave propagation, chemical stability and fairly high mechanical hardness, low dielectric losses and high Curie temperature.

Ferrite nanoparticles have attracted considerable attention because of their particular properties. So, they are intensively studied and developed for industry as information storage, high frequency devices, Ferro fluid and transformers but also in biological applications.

Ferrites are widely used in conventional electronic, electrical, and magnetic devices. For the past two decades, since the discovery of the super paramagnetic nature of nanostructured ferrites, their applications in biotechnology and biomedical sciences as well as in advanced electronics and microwave devices have gained immense attention.

The most significant and most popular use of ferrites is in optics, electronics, mechanics and other technical fields. Ferrites also play a major role in medicine, biomedical applications, as chemical catalysis and special coatings (antistatic, electromagnetic shielding).

Ferrite nanoparticles have attracted an increasing interest because of their scientific aspects and applications in permanent magnets, targeted drug delivery, and high density information storage devices. Ferrite have many important applications in industry, modern telecommunication and electronic devices and they are still of interest as promising materials for miniature electro-optic modulators, hydroelectric detector, piezoelectric sensors, high quality filters, transformer cores, ferrite isolators, memory core industry, multiplayer chip inductor, rod antennas and radio frequency circuits . For these reasons, their applications ranges from simple function devices, such as small permanent magnets to sophisticated devices for the electro-electronic industry. Some interesting applications are in magnetic media used in computers, recording devices, magnetic cards and tapes. The electrical and magnetic properties of ferrites are depending on the processing conditions, sintering temperature, chemical composition and types of additives. Ferrites have become suitable for many technological applications such as microwave devices and telecommunication devices, electric motors and

generators, as excellent core material for power transformers in electronics, antenna rods, loading coils and read / write heads for high speed digital tape, tape recorders and discs, high-density information storage and recording devices and as permanent magnets, sensors, and so on.

The need to obtain new technologies has stimulated the development of new materials, where properties can be controlled and even be substantially better than previously projected. In this regard, one of the main classes of materials is magnetic materials with the strategic interest. At this juncture, the nano magnetism is a specialty that deals with magnetic phenomena especially present in structures with dimensions below the micrometer, i.e. nanometer (10-9 m). This is a field of nano science with a rich and intriguing physics behind and at the same time, it is intimately aligned with new technological challenges, which began with the discovery of giant magneto resistance effect.

The changes in the properties of the nanoparticles are mainly attributed to crystallite size due to the fraction of atoms on the surface compared to the bulk. The copper ferrite bulk belongs to the inverse spinel structure with Cu2+ ions occupying octahedral B-site while Fe3+ ions occupy equally the tetrahedral (A-sites) and octahedral (B-sites) site of the unit cell, this configuration is shown by (Fe3+) A [$Cu^{2+}Fe^{3+}$] BO_4^{2-}. The most widely used methods for synthesis of ferrite nano particles, with range of crystallite size between 1 to 100nm, are sol-gel, co-precipitation and solid state methods. The structural properties will be investigated by X-ray diffraction and by scanning electron microscopy. The magnetic properties will characterized by Mössbauer spectrometry on Fe. The results will be obtained discussed in terms of the annealing -temperature and grain size.

2. REVIEW OF LITERATURE:

Spinal ferrites are interesting materials owing to their wide range of applications in modern science and technology. They have recently attracted considerable research interest on their structural, electrical and magnetic properties. These structures are attractive for microwave applications, magnetic sensors and catalytic materials owing to their great magnetic permeability and dielectric constants, low dielectric loss, high Curie temperature as well as

chemical stability and mechanical strength at low frequencies. In addition, their magnetic properties can be controlled and tailored for practical applications through the appropriate choice from a number of divalent cations in their structure.

Kolekar et al (1) have examined the effect of trivalent substitution in different ferrites to improve their structural, magnetic and electrical proprieties and its effect of the substitution of Gd^{3+}on the thermoelectric power of Cu- Cd ferrite.

Nandu Chaure et al (2) has reported Nanostructured Mg-Ni-Zn ferrite with composition Mn0.1Ni0.6Zn0.3AlxFe(2-x)O4 (where x =0.05, 0.1, 0.15, 0.2) was prepared by sol-gel method. X-ray diffraction (XRD) patterns of all samples showed the spinel structure. Further, the XRD data have been used to calculate the lattice parameter and grain size. The morphology of nano ferrites was studied using scanning electron microscopy. The dielectric permeability, AC and DC resistivity for all compositions were measured. The highest resistivity was measured for the sample with x = 0.1. Vibrating Sample Magnetometry (VSM) was employed to study the magnetic properties of nano ferrites. High saturation magnetization of value 38.7 emu/g, coercivity 7 Oe and highest initial permeability 83.7 was measured for the sample consisting Al concentration, x = 0.05. These nano ferrites may have applications in core materials and in electronic device technology.

Z.H. YANG et al (3) reported Ni0.23Cu 0.11Zn0.66 Fe2O4 ferrite flakes, with thickness of about 8 μm and average diameter of 20–35 μm, were prepared using a sol–gel bubble method. Morphology, phase evolution, static and dynamic magnetic properties of the flakes and their composites were studied. Magnetic measurements showed that easy magnetization direction of the flaky filler composite was parallel to its sample plane. This sol–gel method should be also applicable to fabricating flakes of other multi-component oxides.

M. Siva Ram Prasad et al (4) described Ni0.65-xCdxZn 0.35Fe2O4 ferrites with x varying from 0.00 to 0.20 in steps of 0.04 have been prepared by conventional ceramic route. Calcination and sintering of samples were performed at 950 and 1250 0C for 4 and 2 h, respectively. The prepared samples were characterized by powder X-ray diffraction. The observed modifications in structure and increase in lattice constant are attributed to the difference in ionic radius of substituted Cd2+ ion and displaced Ni2+ ion.

Hong-guo Zhang et al (5) reported a series of Co ferrites (CoxFe3-xO4(x¼-0.1)) were prepared using solid-state method in this work. The aging effect of their structures and constrictions of hysteresis loops under low magnetic field were investigated. It was found that during the aging process, the migration of trivalent (bivalent) ions between tetrahedral (A-site) and octahedral (B-site) coordination induced a shrinking of the lattice, which would expand again due to the precipitation of Fe3+ after a much longer aging time.

Xiaoyan Tan et al (6) described Nano crystalline Ni0.5Cu0.5Fe2O4 was synthesized by sol–gel method with varying calcination temperature over the range of 500–1000. The powders obtained were characterized by X-ray diffraction (XRD), Fourier transform infrared (FT-IR), scanning electron microscopy (SEM), transmission electron microscopy (TEM) and X-ray photoelectron spectroscopy (XPS). In addition, thermal analysis (TG–DTG–DTA) of the precursor was carried out. For the crystalline structure investigated, single cubic spinel is gained when the precursor was decomposed at 800–1000, whereas separated crystal CuO formed when calcination temperature is below 800. The increase of calcination temperature favors the appearance of FeB3+, CuA2+ and O on the spinel surface.

P.B.C.Rao et al (7) described Nickel-zinc ferrites of different compositions Ni(1-x)Zn(x)Fe(2)O(4) with x = 0.40, 0.50, 0.60 and 0.70, have been prepared by a precursor method involving citrate precursors of the concerned metals and mixing them in solution state. Resistivity has been studied as a function of composition and sintering temperature. It is observed that NiZn ferrites prepared by this method have resistivity ≥ 10~ (8) Ωcm which is higher by at least two orders of magnitude than that reported (≤10~ (6) Ωcm) for ferrites prepared by the conventional ceramic method. This is attributed to better purity as well as better compositional and microstructural control achievable by the citrate method. High resistivity makes these ferrites suitable particularly for high-frequency applications where eddy current losses are required to be low.

Jung-Sik Kim et al (8) reported the ultra-fine NiCuZn-ferrite was prepared by a coprecipitation method. The magnetic properties were investigated in terms of calcining temperature. The ferrite powders, Ni0.206Cu0.206Zn0.618Fe1.94O4-d, were initially heat treated at various temperatures of 300–750oC, and then sintered at the final temperature of 900oC. The average particle size calculated by a XRD pattern and confirmed by a transmission electron microscope

(TEM) micrograph was 7.5 nm. The calcining temperature was an important factor for microstructures and magnetic properties of the sintered ferrite. Scanning electron microscope (SEM) micrographs showed a uniform grain growth with small pores and high densification at the calcining temperature of 450oC.

Xiwei Qi et al (9) described that Nano size LaFeo3 powders of 30 nm particle size were directly prepared by sol-gel auto-combustion at room temperature. The overall process involves three steps: formation of homogeneous sol; formation of dried gel; and combustion of the dried gel. Experiments revealed that LaFeO3 dried gel derived from citrate and nitrate sol exhibits self-propagating combustion at room temperature once it is ignited in air. After auto-combustion, the gel directly transforms into Nano sized LaFeO3 particles.

R. H. Kodama et al (10) reported that Nickel ferrite nanoparticles exhibit anomalous magnetic properties at low temperatures: low magnetization with a large differential susceptibility at high fields, hysteresis loops which are open up to 160 kOe, time-dependent magnetization in 70 kOe applied field, and shifted hysteresis loops after field cooling. We propose a model of the magnetization within these particles consisting of ferrimagnetically aligned core spins and a spin-glass-like surface layer. We find that qualitative features of this model are reproduced by a numerical calculation of the spin distribution.

Ounnunkad and Winotai (11) were reported the effect of Cr3+ substitution on M type barium ferrite prepared by a nitrate - citrate gel auto combustion process, concluding that the saturation magnetization systematically decreases with increasing Cr concentrations, whereas the coercivity increases.

Ladgaonkar et al (12) examined the cation distribution and magnetization of Nd3+ substituted Zn-Mg ferrite, and reported an increasing tendency in the occupancy of magnesium ion by substitution of Nd3+.

Rani-et-al (13) have performed that zinc substituted cobalt nano ferrites, with formula Co(1-x)ZnxFe2O4 (x = 0.0, 0.1, 0.2, 0.3, 0.4).The solution combustion method was used .The electric and dielectric properties such as dc resistivity, dielectric constant and dielectric loss are calculated. Analysis of the X-ray diffraction pattern of all the samples confirmed the formation of spinel structure. The surface morphology of the samples is studied by using TEM. The dc

resistivity was found to be increasing with an increasing substitution of zinc ions and the high value of dc resistivity, 108 Ω cm, make these Nano ferrites more suitable at high frequency applications. Dielectric constant and dielectric loss tangent, measured in the frequency range from 1 kHz to 1MHz, are found to be decreasing with an increase in frequency. He finally quoted that these ferrites are suitable for microwave applications.

Suresh R. Kulkarni (14) prepared Nanostructured Mn-Ni-Zn ferrite with composition Mn0.1Ni0.6Zn0.3InxFe (2-x) O4 (x =0.05, 0.1, 0.15, 0.2) . X-ray diffraction (XRD) patterns of all samples showed the spinel structure using sol-gel method. The dielectric permeability, AC resistivity and DC resistivity was measured and it was observed that the sample with x = 0.1 has highest resistivity. Vibrating Sample Magnetometry (VSM) is used to characterize the magnetic properties of prepared Nano ferrites. The maximum saturation magnetization (36.2 emu/g) was observed for the sample with x = 0.1. For the same sample the coercivity was found very small (7 Oe). These materials are expected to have applications in core material and in electronic devices technology.

Mohamad Niyaifar (15) has studied stoichiometric Mn1-xZnxFe2O4 (x=0, 0.1, 0.3 and 0.5) nano-crystalline powders were prepared via sol-gel auto-combustion. X-ray diffraction pattern confirm the existence of single phase of cubic spinel crystal structure with the lattice parameter ranges from 8.378 A0 (x=0) to 8.301 A0 (x=0.5). This behavior was attributed to the ionic radii.The mean particle size of the nano-powders was calculated by Scherrer 'formula. Powder-forming particle size was characterized by scanning electron microscopy (SEM). Magnetic parameters of the prepared nano powders were measured by vibrating sample magnetometers (VSM). Also using an LCR-meter, the Curie temperature of each sample was measured. The obtained results showed that with the increasing the amount of zinc in nano powders Mn-Zn ferrite, Curie temperatures were decreased but magnetic saturation was slightly increased and by adding more zinc it starts to decrease. Infrared (IR) spectra of Zn2+ ions substituted Mn-Zn spinel ferrite, have been analyzed in frequency range (400-4000) cm-1. The main tow absorption bonds in IR spectra were observed in frequency range (400-600) cm-1. The absorption bonds are caused by the metal-oxygen vibrations in octahedral and tetrahedral sites.

Sonal Singhal (16) has reported nanoparticles of Co0.5Zn0.5AlxFe2_xO4 (x = 0, 0.2, 0.4, 0.6, 0.8 and 1.0) were synthesized by sol–gel method and the influence of Al3+ doping on the properties of Co0.5Zn0.5Fe2O4 was studied. X-ray diffraction studies revealed the formation of single phase spinel type cubical structure having space group Fd-3m. A decreasing trend of the lattice parameter was observed with increasing Al3+ concentration due to the smaller ionic radii of Al3+ ion as compared to Fe3+ ion. TEM was used to characterize the microstructure of the samples and particle size determination, which exhibited the formation of spherical nanoparticles. The particle size was found to be increases up to _45 nm after annealing the sample at 1000 8C. Electrical resistivity was found to increase with Al3+ doping, attributed to the decrease in the number of Fe2+–Fe3+ hopping. The activation energy decreased with increasing Al3+ ion concentration, indicating the blocking of conduction mechanism between Fe3+–Fe2+ ions. The value of saturation magnetization decreased, when Fe3+ ions were substituted with Al3+ ions in Co0.5Zn0.5Fe2O4; however, the coercivity values increased with increasing Al3+ ion content.

G. Venkaiah at al (17) discussed about the synthesis of the nano sized crystalline Lanthanum Ferrite (LaFeO3) by solution combustion synthesis where lanthanum nitrate, iron nitrate were taken as metal precursors and glycine was taken as fuel. The ratio of fuel to oxidizer was taken as one (Ψ =1). The prepared nanocrystalline LaFeO3 were characterized by X-ray diffraction, Thermo gravimetric and differential thermal analysis, Nano particle size analyzer, UV-Visible absorption spectrometer, Scanning Electron Microscopy with Energy Dispersive X-ray Analysis spectrum (EDAX) and the investigation of magnetic properties showed in hysteresis curve used.

Hong-guo Zhang et.al (18) reported a series of Co ferrites (CoxFe3-xO4(x¼-0.1)) were prepared using solid-state method in this work. The aging effect of their structures and constrictions of hysteresis loops under low magnetic field were investigated. It was found that during the aging process, the migration of trivalent (bivalent) ions between tetrahedral (A-site) and octahedral (B-site) coordination induced a shrinking of the lattice, which would expand again due to the precipitation of Fe3+ after a much longer aging time.

Xiwei Qi,et.al (19) described that Nano sized LaFeo3 powders of 30 nm particle size were directly prepared by sol-gel auto-combustion at room temperature. The overall process

involves three steps: formation of homogeneous sol; formation of dried gel; and combustion of the dried gel. Experiments revealed that LaFeO3 dried gel derived from citrate and nitrate sol exhibits self-propagating combustion at room temperature once it is ignited in air. After auto-combustion, the gel directly transforms into Nano sized LaFeO3 particles.

E. A. Eremina et.al (20) stated that Fine zinc ferrite (ZnFe2O4) powders uniform in morphology have been prepared by spray pyrolysis of nitrate solutions. Examination by scanning electron microscopy showed that the powders consisted of micron- and submicron-sized polycrystalline spherical particles. The ZnFe2O4 sample prepared by pyrolysis at 1000° C had paramagnetic properties.

Despite of many other attempts, there is no specific report on the trivalent substitution of La substituted Nickel, Cobalt, Zinc ferrite Nano powders to the best of our knowledge. Therefore we are interested to investigate the properties of La substituted Nickel, Cobalt, Zinc ferrite by simplest sol-gel autocombustion technique.

3. a) OBJECTIVES OF RESEARCH:

- To choose proper method for Synthesis says sol-gel autocombustion method.
- To Design, Develop and Installation for it.
- To synthesize Nano crystalline $Ni_xCu_xGD^{3+}_yFe_{2-y}O_4$ where x = 0.5 and y < 0.2 has to prepare by using metal nitrates, to investigate the properties of Gadolinium substituted Ni-Cu ferrite by simplest sol-gel autocombustion technique.
- To synthesize Nano crystalline $Ni_xZn_xGd^{3+}_yFe_{2-y}O_4$ where x = 0.5 and y < 0.2 has to prepare by using metal nitrates, to investigate the properties of Gadolinium substituted Ni-Zn ferrite by simplest sol-gel autocombustion technique.
- To synthesize Nano crystalline $Zn_xCu_xGd^{3+}_yFe_{2-y}O_4$ where x = 0.5 and y < 0.2 has to prepare by using metal nitrates, to investigate the properties of Gadolinium substituted Zn-Cu ferrite by simplest sol-gel autocombustion technique.
- Also $Ni_xZn_xCu_xGd^{3+}_yFe_{2-y}O_4$ where x = 1 and y < 0.2 has to prepare by using metal nitrates to investigate the properties of Gd^{3+} substituted ferrite.
- To Investigating the exact growth mechanism and effect of Gd^{3+} substituted in preparation of nanocrystalline ferrite materials.

- To study the properties of prepared sample using the characterizations Thermo Gravimetric and Differential Thermal (TGDT), X- ray diffraction (XRD), Fourier Transforms Infrared Spectroscopy (FTIR), UV-visible absorption Spectra, Transmission Electron Microscope (TEM), Scanning Electron Microscopy (SEM) and Vibrating Sample Magnetometer (VSM) for magnetic properties.
- To study the role of various system parameters in determining the electric, magnetic and structural properties of the material.
- To study reasons behind the superiority of the materials produced by method.

b) HYPOTHESIS:

Among the various soft chemical routes, sol-gel technique, method were particularly successful in the preparations of bulk metal oxides. (Example: films, glasses, ceramics and fibers). Therefore, they also have been applied for nanoparticle synthesis. But in spite of great efforts, the number of oxidic nanoparticles obtained by sol-gel process rather than other powder routes. It turned out that in many cases a synthesis protocol developed for a bulk metal oxide could not directly be adapted to its corresponding counter art on the nanoscale.

4. METHODOLOGY TO BE ADOPTED:

The Sol-gel process is the conversation of a precursor solution into an inorganic solid via polymerization reaction induced by water. The metal oxides are most widely used precursor because they react rapidly with water. The sol-gel process is also called as chemical solution deposition or wet-chemical technique which widely used in the fields of materials science and ceramic engineering for the fabrication of metal oxide materials starting from a chemical solution say *sol* that acts as the precursor for an integrated network say *gel* of either discrete particles or network polymers.

Sol-gel process consists of following steps.

1. Preparation of homogeneous solution of either by dissolution of metal organic precursors in an organic solvent that is miscible with water, or by dissolution of inorganic salts in water.
2. Conversion of the homogeneous solution into a sol by treatment with a suitable reagent (Generally water with or without any acid/base).

3. Maintaining the pH as solution by using a liquid (ammonia liquid).
4. By using continuous heat treatment, the formation of gel.

It offers a specific advantage in the precipitation of multi-component oxides ceramics. The early formation of gel provides high degree of homogeneity and reduces the need of atomic diffusion during solid state calcinations. In this precipitation, a solution of appropriate precursors (metal salts or metal organic compounds) is formed first followed by the conversion into homogeneous oxide network after hydrolysis and condensation. Drying and subsequent calcinations of gel yields an oxide product. For preparation, alkoxides are mixed together in alcohol. Hydrolysis can carried out under controlled temperatures, pH and concentration of alkoxides, added water and alcohol. However, the relative high cost of alkoxides may be prohibitive for certain applications.

In this study, Sol-gel method is utilized because of its advantage of good stoichiometric control and the production of ultrafine particles in a relatively short processing time at lower temperatures.

For mass production of Nanocrystalline Ferrite materials, we need a technique which is cost effective and can be easily scaled up. Sol-gel technique meets these requirements and many reports have been already published.

Following **stepwise approach** will be undertaken to achieve the objectives stated in the research proposal.

Step-I: Design, develop and installation of the basic infrastructure namely sol-gel autocombustion technique.

Process: Gadolinium Gd3+ nitrate, Ferric nitrate, Copper nitrate, Nickel nitrate, Zinc nitrate are used as a AR-grade raw material while Citric acid as a fuel to prepare composition of $Ni_xCu_xGd^{3+}_yFe_{2-y}O_4$, $Ni_xZn_xGd^{3+}_yFe_{2-y}O_4$, $Zn_xCu_xGd^{3+}_yFe_{2-y}O_4$ and $Ni_xZn_xCu_xGd^{3+}_yFe_{2-y}O_4$ using the stoichiomertic ratio. The distilled water is used as a solvent. The solution is stirred for 15-20 minutes to obtain the homogeneous solution. During constant stirring few drops of ammonia solution are added to maintain the pH of 7. The solution is continuously stirred with heated around 90^0C–100^0C becomes gel form within 3-4 hrs. Approximately after 1/2 hours, the

autocombustion takes place and obtain ferrite powder. Then this powder is finely grinded and sintered for further characterization.

Step-II: Synthesis of Gd3+ substituted Zinc-Nickel-Copper ferrite Nano crystalline powder. The dependence on physical properties of the various combinations of nitrate citrates will be investigated.

Step-III: To study the characterization of the $Zn_xNi_xCu_xGd^{3+}_yFe_{2-y}O_4$ at different compositions.

Following techniques will be used for the characterization.

ii) **Magnetic Properties:**

Vibration Sample Magnotometry (VSM), Magnetic Permeability, Magnetic Coercivity

i) **Structural properties:**

Thermo Gravimetric and Differential Thermal (TGDT), Fourier Transform Infrared (FTIR) spectroscopy, X-ray diffraction (XRD), Scanning Electron Spectroscopy (SEM), Transmission Electron microscope (TEM) at different sintering temperatures

iii) **Optical Properties:**

UV Spectroscopy

iv) **Electrical properties:**

AC, DC resistivity

5. IMPORTANCE OF STUDY:

International Status:

Spinal ferrites are interesting materials owing to their wide range of applications in modern science and technology. They have recently attracted considerable research interest on their structural, magnetic, and electrical properties. These structures are attractive for microwave applications, magnetic sensors and catalytic materials owing to their great magnetic permeability and dielectric constants, low dielectric loss, high Curie temperature as well as mechanical strength and chemical stability at low frequencies. The sol-gel autocombution is used to prepare the nanocrystalline ferrite materials. Several industry related sectors like electronics and IT appears poised to gain from nanotechnology applications which appears that nanotechnology could impact on social development, economics and businesses the world

over. It will understand the origin of nanoscience and nanotechnology. We can really understand influence of nano science on human life. Tracing back to the invention related to nanotechnology within the context of textiles, it has come to light that the technology related to the manufacturing of nanofibres using synthesis methods is over a century old. The process of dispersing fluid using electrical charges which formed the basis for developing solvent cum electro-spun nanofibres dates back to the year 1902 with the granting of two separate and independent patents (US) on dispersing fluids and in 1940, Formhals was granted a patent for using electrical charges to develop synthetic threads.

National Status:

In Our view, the cost of such nano enhanced products will not be an issue in the healthcare, environment, defense, aerospace and advanced technology sectors. In addition, because of the nature of the nanotechnology and its size, it gives immense opportunities for small and medium sized enterprises to venture into this field. We endeavor to provide a new, albeit simple method of classifying nanofibers based on the dispersion process by which they are produced.

Significance of the study:

Ferrite materials possess properties of both magnetic materials and electric insulator. Magnetic and electric properties make ferrites as an important material in many technological applications and these preferred because of their permeability in the radio frequency region, high electrical resistivity, mechanical hardness, chemical stability etc. There is a growing interest of researchers from last few decades in nanocrystaline ferrites. The properties of these nanocrystalline ferrites particles are considerably different from those of bulk counterpart. The nanocrystalline ferrites can be prepared by techniques. Number of chemical methods was developed to prepare nanocrystalline ferrites like wet chemical, microwave refluxing, sol-gel, hydrothermal etc. Processing of ferrites has gained tremendous importance in recent times to meet the high performance demands on ferrites in keeping pace with the vast emerging technologies.

Scope:

With the advent of nanotechnology, a tremendous surge in research on miniaturization and high efficiency electronic device is on rise. These modern devices exclusively need soft

magnetic materials as its basic magnetic component. Soft ferrite materials are extensively used in inductors which from a basic requirement in high technology areas. Ni Cu Zn ferrites are adequately suit these demands and considered to shape the future of advanced technology.

Applications of Work

The Ni-Cu-Zn ferrite is the most important magnetic material used for the manufacturing of

1. Magnetic coating.
2. Multilayer chip inductors.
3. Capacitors.
4. Tremendous surge in research on miniaturization.
5. High efficiency electronic devices

6. PROPOSED WORK PLAN/FORMULATION AND STRUCTURE OF STUDY:

i) First six month(6 Month)

- Literature survey
- Data Collection
- Provision of chemicals for preparation of samples.
- Weighing of ingredients
- Preparation (Experiment) of Powder by autocombustion method.
- Pre-sintering and slow cooling.
- Final sintering of the samples

ii) One Year (12 Months)

- Characterization of powder samples by TGDT, UV and X-ray diffraction technique and analysis for the calculation of various parameters.
- Characterizations of powder samples by Infrared absorption technique (FTIR) and analysis.
- Characterizations of powder samples by scanning electron microscopic (SEM) and Transmission Electron microscopy (TEM) and analysis.
- Course work completion.

iii) One year and six months(18 Months)

- Structural study of the samples.

- Electrical DC and AC conductivity (LCR meter) properties of samples.
- Magnetic (VSM) study of the samples.
- Analysis of Result and Conclusions.
- Writing of research paper.

iv) Two year(24months)

- Thesis Writing.
- Typing and binding of the research thesis.
- Submission of thesis.

Out Come Expected

Proposed work is to synthesis nanocrystalline ferrite and study the effect of Gd3+ substituted ferrite by sol-gel autocombustion technique.

- Influence of Gd3+ doping in the formation of Nickel / Cupper / Zinc ferrite nonmaterial.
- The exact growth mechanism of Gd3+ substituted ferrite by sol-gel autocombustion technique.
- Influence of various combinations of nitrates-citrate on magnetic, electrical, structural, and optical properties of Gd3+ substituted Nickel / Cupper / Zinc ferrite Nano crystalline powder.
- Optimization of the best suitable combination of various composition.

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C E R T I F I C A T E

This is to certify that the synopsis entitled " **SYNTHESIS AND CHARACTERIZATION OF GADOLINIUM (Gd^{3+}) DOPED Ni, Cu, Zn NANOFERRITES "** prepared by **MR. PHUNDE BABASAHEB ESHWAR** as a partial fulfillment for the requirement of the degree of Doctor of Philosophy in **PHYSICS.**

Research Guide
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